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ARMY SERVICE FORCES
UNITED STATES ENGINEER OFFICE
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KZ 5118 5 AIN REPLY
REFER TO

MD-729.3 Radiation

P. O. Box E

5-27006

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12 May 1945

Subject: Radioactivity of K-25 Product as a Health Hazard

MEMORANDUM to the Files

REPORT NO.

KZ 5118

A. Physical Considerations

1. Dr. R. Benedict furnished data giving the approximate mol % of T_{11} ²³⁴ in K-25 product at several percentages of T_{235} , correct to within 25%.

Mol %

T_{235}	T_{11}^{234}	Ratio of 234/235
1.1	0.0095	.0086
5	0.049	.0098
10	0.105	.0105
20	0.22	.011
36.6	0.44	.012

Calculations will be made assuming a concentration of 10% for T_{235} . The constitution of K-25 product would then be approximately:

T_{235}	20.0%
T_{11}^{234}	.22%
T_I^{238}	79.78%

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Thomas W. Kelley 4/15/96
Date 4/16/96These figures neglect the minute amounts of T_{12} , T_{13} , T_{14} and T_{15} present.The enhancement over normal material would be in this case about 35 for T_{235} and 46 for T_{234} .

2. Alpha activity.

For normal material, the alpha energy output in Mev per second per gram may be calculated as follows:

 $E = \text{energy output per second per gram of material containing several elements, in Mev.}$

$$\begin{aligned}
 n^2\alpha &= (.93)(1.33 \times 10^4)(4.2 \times 4.8) \\
 &\neq (.0071)(7.9 \times 10^4)(4.52) \\
 &= 11.7 \times 10^4 \neq .254 \times 10^4 \\
 &= 1.21 \times 10^5 \text{ kev.}
 \end{aligned}$$

For the $\bar{\Lambda}-25$ product assumed, the same calculation gives

$$\begin{aligned}
 n^2\alpha &= (.798)(1.33 \times 10^4)(4.2) \\
 &\neq (.20)(7.9 \times 10^4)(4.52) \\
 &\neq (.0022)(2.10 \times 10^8)(4.8) \\
 &= 4.45 \times 10^4 \neq 7.15 \times 10^4 \neq 222 \times 10^4 \\
 &= 2.34 \times 10^5 \text{ kev.}
 \end{aligned}$$

The alpha particle energy output of this product would then be about 19 times that of normal material.

3. Beta activity

It is expected that only equilibrium amounts of $\beta\beta 1$ and $\beta\beta 2$ will be present in the $\bar{\Lambda}-25$ product. The beta energy output for normal material in kev per second per gram may be calculated as follows:

$$\begin{aligned}
 3 \times \beta &= (.993)(1.33 \times 10^4)(0.13 \neq 2.32) \\
 &\neq (.0071)(7.9 \times 10^4)(0.2) \\
 &= 3.24 \times 10^4 \neq 0.112 \times 10^4 \\
 &= 3.25 \times 10^4
 \end{aligned}$$

The factor 3 is introduced to convert the peak beta ray energies used in the calculation to average values.

or $\beta = 1.08 \times 10^4$ kev

$\alpha \beta$

For product of the given enhancement

$$\begin{aligned}
 3 \times \beta &= (.798)(1.33 \times 10^4)(0.13 \neq 2.32) \\
 &\neq (.20)(7.9 \times 10^4)(0.2) \\
 &= 2.60 \times 10^4 \neq 0.316 \times 10^4 \\
 &= 2.92 \times 10^4
 \end{aligned}$$

or $\beta = .97 \times 10^4$ kev

$\alpha \beta$

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The beta activity of this product would therefore be about 90% that of normal material.

4. Gamma activity.

The gamma activity will follow the concentrations of Th_1 and Th_2 and in K-25 product will therefore be about 90% of the gamma activity of normal material.

B. Biological Considerations.

1. On the basis that 0.1 microgram of radium fixed in the bones over a period of at least several years is the tolerance amount, the corresponding amount of K-25 product would be 24 milligrams. Also, it may be calculated that about 31 milligrams uniformly distributed in the lungs would cause tissue ionization equivalent to 0.1 roentgen.

2. Assuming that about 36% of inhaled material is retained in the lungs, that 10% of inhaled material remains after 2 months, and that, after this, excretion from the lungs is slow (figures for another material), it may be calculated that 31 mgs of K-25 product will collect in the lungs in two years if the atmospheric concentration is 126 micrograms per cubic meter. (This assumes exposure for 8 hours daily during which time the air exchange is 5 cubic meters) Since 31 mgs, equivalent to 0.1r, in the lungs is not reached for 2 years, it may be assumed that the same concentration over three years would give an average dose throughout the three years of 0.1r.

For the present, it seems wise to introduce a factor of about 3 into the above value in order to derive an allowable atmospheric concentration over a period of 3 years. This factor is necessary because of uncertainties in the relative biological effect of alpha vs. gamma ionization, in the absorption and excretion data, and in the daily air exchange. The tolerance amount in the atmosphere for K-25 product may be tentatively set therefore at 35 micrograms per cubic meter. The limiting factor in the above calculation is assumed to be pulmonary irradiation. The level which would be set on the assumption that a similar rate of deposition occurs in the bones would be considerably higher.

3. The tolerance time for skin contact with "infinite" thickness of normal material has been set at two hours. The same figure may be used for K-25 product since enhanced alpha activity does not constitute an increased hazard to the skin.

4. Further investigation may produce a biological test for excessive exposure in individuals. Urinary determinations of T excretion should be done at frequent intervals in order to spot any excessive exposure.

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BERNARD S. WOLF
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